Agenda Item No. 5A
Application No. 18312-BD
Mitigation for Tisdale Rehabilitation Project at Colusa-Sacramento River State Recreation Area, Colusa County

Agenda Item Description
Consider approval of application number 18312-BD for the off-site mitigation related to the Tisdale Bypass Rehabilitation Project. The off-site mitigation will involve planting of riparian forest, savannah and grassland. The site is in the Colusa-Sacramento River State Recreation Area, near the Colusa Weir in Colusa County.

Project Location
The project area is within the leveed floodway of the Sacramento River immediately north of the town of Colusa in Colusa County, California. The site is within Section 19 of T 16N, R1W as shown on the Colusa 7.5' USGS quadrangle. The project site is a 139.4-acre agricultural field at River Mile 145.5. A project location map is attached as Appendix A.

Project History
The project site is part of the Colusa–Sacramento River State Recreation Area (SRA) and is owned and managed by California Department of Parks and Recreation (DPR). It is part of a 238-acre parcel called the *Ward Tract*, which DPR acquired in early 2007 from The Nature Conservancy (TNC). Agricultural use of the property has been continued by TNC and DPR via annual lease. Lima beans were grown on the site in summer 2007, but orchards and other row crops were grown on portions of the site in years past. The California Department of Water Resources (DWR) is seeking to provide mitigation for the reduction in riparian forest acreage due to the removal of sediment from the Tisdale Bypass, part of the federal-state Sacramento River Flood Control Project. This mitigation can be provided (in addition to additional advance mitigation credit), by restoring native riparian habitat to the Ward Tract.

DWR's primary purpose and objective in restoring riparian forest at this location is to mitigate for the loss of 28.5 acres of riparian forest in the Tisdale Bypass, as a result of a bypass-rehabilitation project conducted by DWR in the summer of 2007. To meet mitigation standards for riparian habitat mitigation required by the U.S. Army Corps of Engineers, 77.5 acres of woody riparian forest must be restored at an off-site location.

DWR's second purpose is to provide mitigation in advance of flood maintenance projects that are expected to impact riparian vegetation within the Sacramento River Flood Control Project in the near future. DWR's anticipated need in the next 10 years is approximately 250 acres of riparian-vegetation mitigation. The Colusa site can accommodate about 93 acres of riparian forest planting and another 11 acres of riparian savanna, and DWR seeks to restore all of these acres at one time. This action will

provide about 26.5 acres of advance mitigation, for which DWR will seek credit from the regulatory agencies.

Project Design
Vegetation at the project site will be restored to mixed riparian forest, cottonwood riparian forest, riparian savanna, and grassland, using all native species. Refer to the attached Planting and Irrigation Plan in Appendix D. On the north project area boundary, the savanna leading south to the grassland is intended to provide minimal resistance to floodflows crossing the site. The grassland is arranged to allow flood flows to pass uninterrupted. The grassland will be mowed biannually to prevent succession to additional riparian forest habitat. The other vegetation types would be left unmanaged, except for suppression of noxious weeds, plant diseases, or fires.

A hydraulic model was created to assess the hydraulic impacts of the proposed planting design. Comparisons between existing conditions and proposed restored conditions with respect to stage, flow and velocity changes were evaluated. The proposed mitigation project has minimal impacts on river stage and velocity and the project design profile will not be exceeded. Refer to the DWR Review of Ayres Associates' Colusa Subreach Model for Ward Tract Restoration in Appendix E.

Four locations where the modeling indicated erosion might be of concern due to high velocities under existing conditions were evaluated in the field. Examinations indicated that levee conditions are competent to withstand the projected existing condition (without project) and restored condition (with project) velocities. DWR concluded that the proposed restoration project at Ward Tract will not compromise the Sacramento River Flood Control System nor adversely affect neighboring properties. Within Appendix E, refer to Appendix D for details.

Need for Application No. 18312-BD
This project is needed to fulfill DWR's permit obligations to the U.S. Army Corps of Engineers for the work that occurred within the Tisdale Bypass during the summer of 2007. The Tisdale Bypass Rehabilitation Project removed 1.7 million cubic yards of accumulated sediment from within the bypass to maintain the system's flood carrying capacity. In order to complete the project and meet the design goals, 28.5 acres of riparian forest were removed. At a 3 to 1 mitigation ratio, DWR is obligated to replace 85.5 acres of riparian forest. To maintain the bypass for its designed function, only 8 acres can be planted within the Tisdale Bypass. The remaining 77.5 acres must be planted at an off-site location. The Ward Tract within the Colusa-Sacramento River State Recreation Area was chosen for many reasons, including its similarity in habitat to the Tisdale Bypass area and the fact that the Department of Parks and Recreation owns the land. Planting at the site is expected to begin in the fall of 2008 for the grassland and the spring of 2009 for the forested areas.

If this work does not proceed, DWR will be out of compliance with federal permits and will incur penalties. Another mitigation site project would have to be initiated and many months of planning for DWR and DPR would be lost.

Appendix: Supporting documents contained in this packet

A. Project Location Map

B. Application for a Reclamation Board Encroachment Permit

C. Environmental Assessment Questionnaire for Applications for Reclamation Board Encroachment Permits

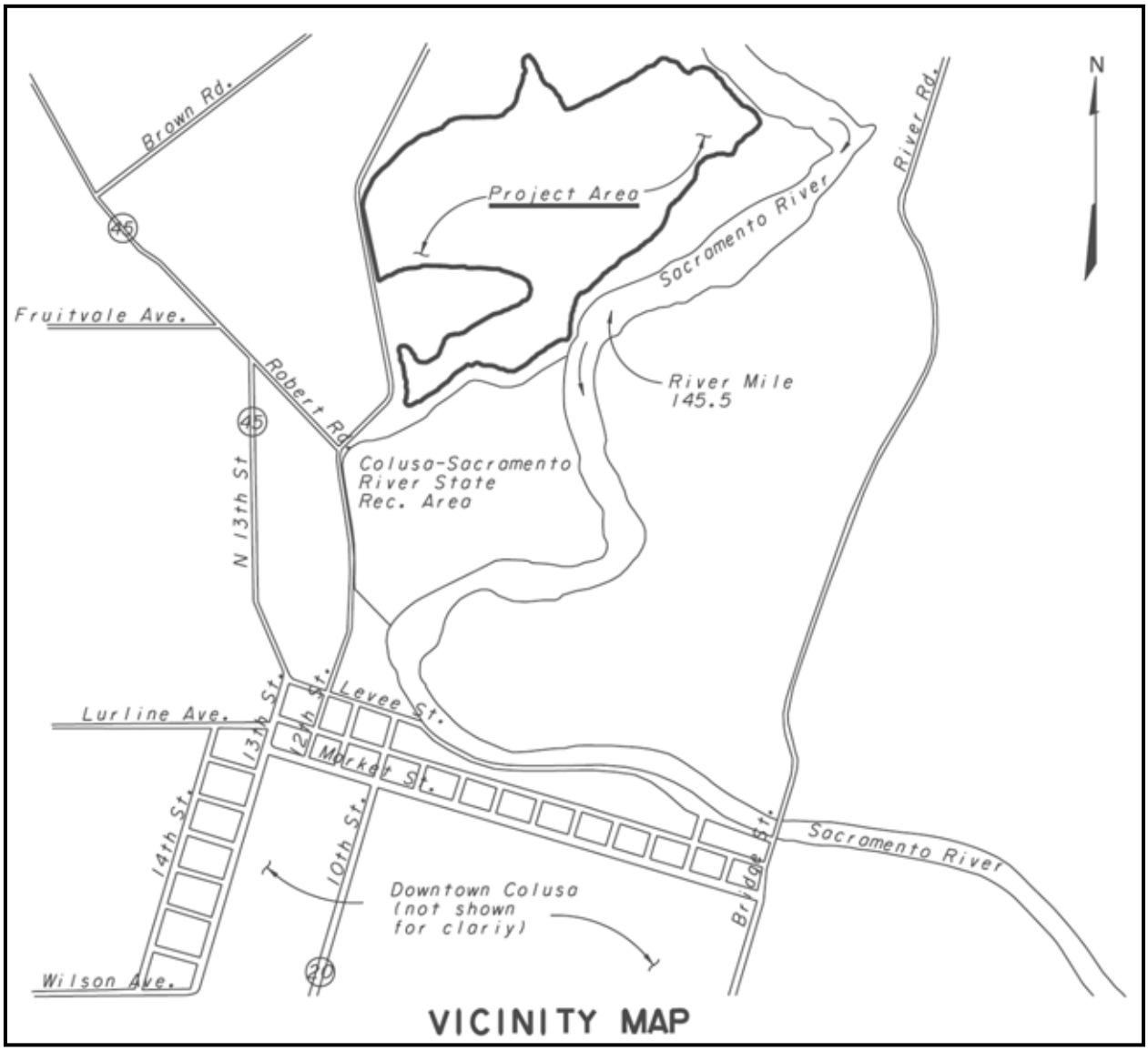
D. Colusa Ward Restoration Planting and Irrigation Plan

E. DWR Review of Ayres Associates' Colusa Subreach Model for Ward Tract Restoration

Appendix A

Project Location Map

Colusa Ward Restoration Area



Appendix B

Application for a Reclamation Board Encroachment Permit

APPLICATION FOR A RECLAMATION BOARD ENCROACHMENT PERMIT

Application No. _____
(For Office Use Only)

1. Description of proposed work:
Mitigation for impacts to riparian habitat caused by Tisdale Bypass rehabilitation project in 2007. Restore habitat on 139 acres of field cropland at Colusa State Recreation Area (SRA), including 35 acres of grassland, 11 acres of oak savannah and 93 acres of riparian forest.

2. Location: Colusa-Sacramento River SRA, Colusa County, in Section _____,
Township: 16 N (N) (S), Range 01 W (W), M. D. B. & M.

3. CA Dept of Water Resources (Name of Applicant) of 3310 El Camino (Address)

Sacramento	CA	95821	916-574-2243
City	State	Zip Code	Telephone Number

916-574-0331
Fax Number

4. Endorsement: (of Reclamation District)
We, the Trustees of NA--CA DWR is maintaining agency
Name and District Number

approve this plan, subject to the following conditions:

☐ Conditions listed on back of this form ☐ Conditions Attached ☒ No Conditions

Trustee	Date	Trustee	Date

5. Names and addresses of adjacent property owners sharing a common boundary with the land upon which the contents of this application apply. If add ional space is required, list names and addresses on back of the application form or an attached sheet.

Name	Address	Zip Code
CA Dept. of Parks and Recreation	400 Glen Drive Oroville	95966
Warren Halsey	PO Box 189, Monroe, OR	97456
Christopher Cherney	PO Box 604, Colusa	95932
Laurie Forry	4300 River Road, Colusa	95932

6. Has an environmental determination been made of the proposed work under the California Environmental Quality Act of 1970? ☐ Yes ☐ No ☒ Pending

If yes or pending, give the name and address of the lead agency and State Clearinghouse Number:

DWR, 3310 El Camino Ave, Sacramento CA 95821

SCH No. _____

7. When is the project scheduled for construction? August 2008 through May 2009

8. Please check exhibits accompanying this application.

   A. ☒ Map showing the location of the proposed work.

   B. ☒ Drawings showing plan and elevation views of the proposed work, scale, materials of construction, etc.

   C. ☒ Drawings showing the cross section dimensions and elevations of levees, berms, stream banks, flood plain, low flow, etc.

   D. ☒ Drawings showing the profile elevations of levees, berms, flood plain, low flow, etc.

   E. ☒ Photograph depicting the project site.

9. Is the applicant acting for the owner of the proposed works? ☒ Yes ☐ No

If yes, the name, address and telephone number of the owner is

CA Dept. of Parks and Recreation, 400 Glen Drive, Oroville CA 95966

_____
Signature of Applicant Date

For additional information:

Refer to the initial study attached for detailed description, maps and pictures. A final hydrualic analysis for elevations of levees, river, and project site as well as description of hydraulic impact analysis is very near completion and will be provided before the final filing date.

Appendix C

Environmental Assessment Questionnaire for Applications for Reclamation Board Encroachment Permits

ENVIRONMENTAL ASSESSMENT QUESTIONNAIRE FOR APPLICATIONS FOR RECLAMATION BOARD ENCROACHMENT PERMITS

This environmental assessment questionnaire must be completed for all Reclamation Board applications. Please provide an explanation where requested. Incomplete answers may result in delays in processing permit applications. Failure to complete the questionnaire may result in rejection of the application.

1. Has an environmental assessment or initial study been made or is one being made by a local or State permitting agency in accordance with the California Environmental Quality Act?

   ☒ Yes ☐ No If yes, identify the Lead Agency, type of document prepared or which will be prepared, and the State Clearinghouse Number:

   Ca Dept. of Parks and Recreation

   Mitigated Negative Declaration

2. Will the project require certification, authorization or issuance of a permit by any local, State or federal environmental control agency?

   ☒ Yes ☐ No List all other governmental permits or approvals necessary for this project or use, including U.S. Army Corps of Engineer' 404and Section 10 permits, State Water Quality Certification, Department of Fish and Game 1600 agreement, etc. Attach copies of all applicable permits.

   Section 404, Section 401, DFG 1600 agreement,

3. Give the name and address of the owner of the property on which the project or use is located. Please submit a copy of your current Title Report (Grant Deed), if your proposed project includes a private residence.

   CA Dept. of PArks and Recreation

   400 Glen Drive

   Oroville CA 95966

4. Will the project or use require issuance of a variance or conditional use permit by a city or county?

   ☐ Yes ☒ No Explain:

5. Is the project or use currently operating under an existing use permit issued by a local agency?

   ☐ Yes ☒ No Explain:

6. Describe all types of vegetation growing on the project site, including trees, brush, grass, etc.

   commercial lima beans

7. Describe what type of wildlife or fish may use the project site or adjoining areas for habitat, food source, nesting sites, source of water, etc.

   See attached Initial Study

8. Has the Department of Fish and Game, U.S. Fish and Wildlife Service, or National Marine Fisheries Service been consulted relative to the existence of, or impacts to, threatened or endangered species on or near the project site?

   ☒ Yes ☐ No Explain:

   A Biological Assessment is in preparation and will be reviewed by the fish and wildlife agencies

9. Will the project or use significantly change present uses of the project area?

   ☒ Yes ☐ No Explain:

   Convert field-crop agriculture to habitat

10. Will the project result in changes to scenic views or existing recreational opportunities?

    ☐ Yes ☒ No Explain:

11. Will the project result in the discharge of silt or other materials into a body of water?

    ☐ Yes ☒ No Explain:

12. Will the project involve the application, use, or disposal of hazardous materials?

☒ Yes ☐ No If yes, list the types of materials, proposed use, and disposal plan. Provide copies of all applicable hazardous material handling plans.

herbicides for weed control. Please see attached Initial Study

13. Will construction activities or the completed project generate significant amounts of noise?

☐ Yes ☒ No Explain:

14. Will construction activities or the completed project generate significant amounts of dust, ash, smoke, fumes, or odors?

☐ Yes ☒ No Explain:

15. Will the project activities or uses involve the burning of brush, trees, or construction materials, etc?

☐ Yes ☒ No Explain, and identify safety and air pollution control measures:

16. Will the project affect existing agricultural uses or result in the loss of existing agricultural lands?

☒ Yes ☐ No Explain:

the crop will switch from lima beans to native plants.

17. Have any other projects similar to the proposed project been planned or completed in the same general area as the proposed project?

☒ Yes ☐ No Explain and identify any other similar projects:

Seven parcels of land in the Colusa Subreach of the Sacramento River have been identified as potential sites for habitat restoration

18. Will the project have the potential to encourage, facilitate, or allow additional or new growth or development?

☐ Yes ☒ No Explain:

19. Will materials be excavated from the floodplain?

☐ Yes ☒ No If yes, please answer the remaining questions.

THE REMAINING QUESTIONS MUST ONLY BE ANSWERED IF THE ANSWER TO QUESTION NO. 19 WAS "YES". IF THE ANSWER TO QUESTION NO. 19 WAS "NO", YOU DO NOT NEED TO COMPLETE THE REMAINING QUESTIONS.

A. What is the volume of material to be excavated?

Annually _____ Total _____

B. What types of materials will be excavated?

C. Will the project site include processing and stockpiling of material on site?

☐ Yes ☒ No Explain:

D. What method and equipment will be used to excavate material?

A trencher will be used to dig trenches for installation of underground irrigation pipe

E. What is the water source for the project?
Sacramento River or on-site wells

F. How will waste materials wash water, debris, and sediment be disposed of?
project will follow requirements in a Sec 402 Stormwater permit from the RWQCB

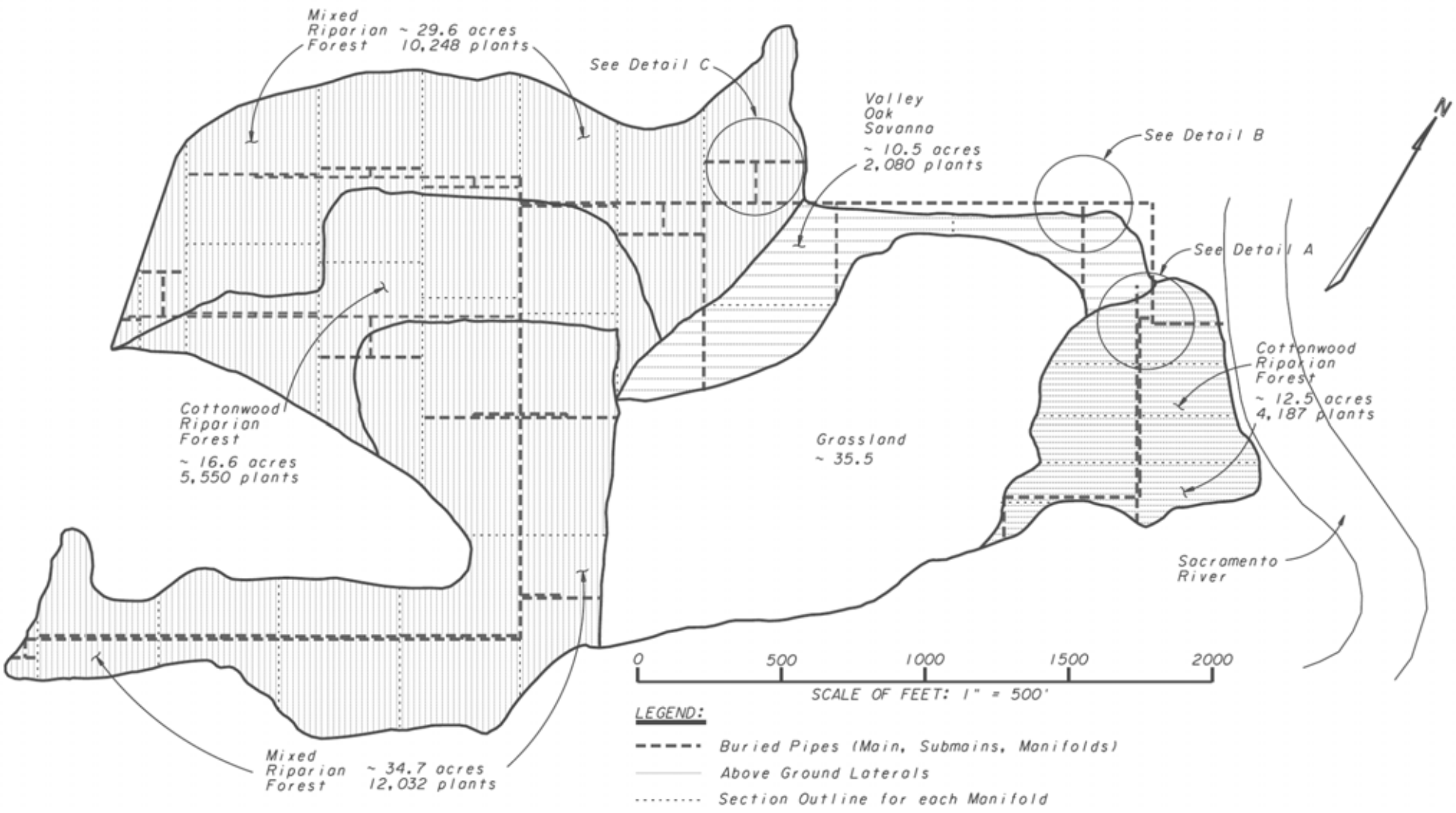
G. What is the proposed end land use for the project site?
habitat and outdoor recreation

H. Has a reclamation plan been prepared for this site in accordance with the Surface Mining and Reclamation Act of 1975?
☐ Yes ☒ No If yes, please attach a copy.

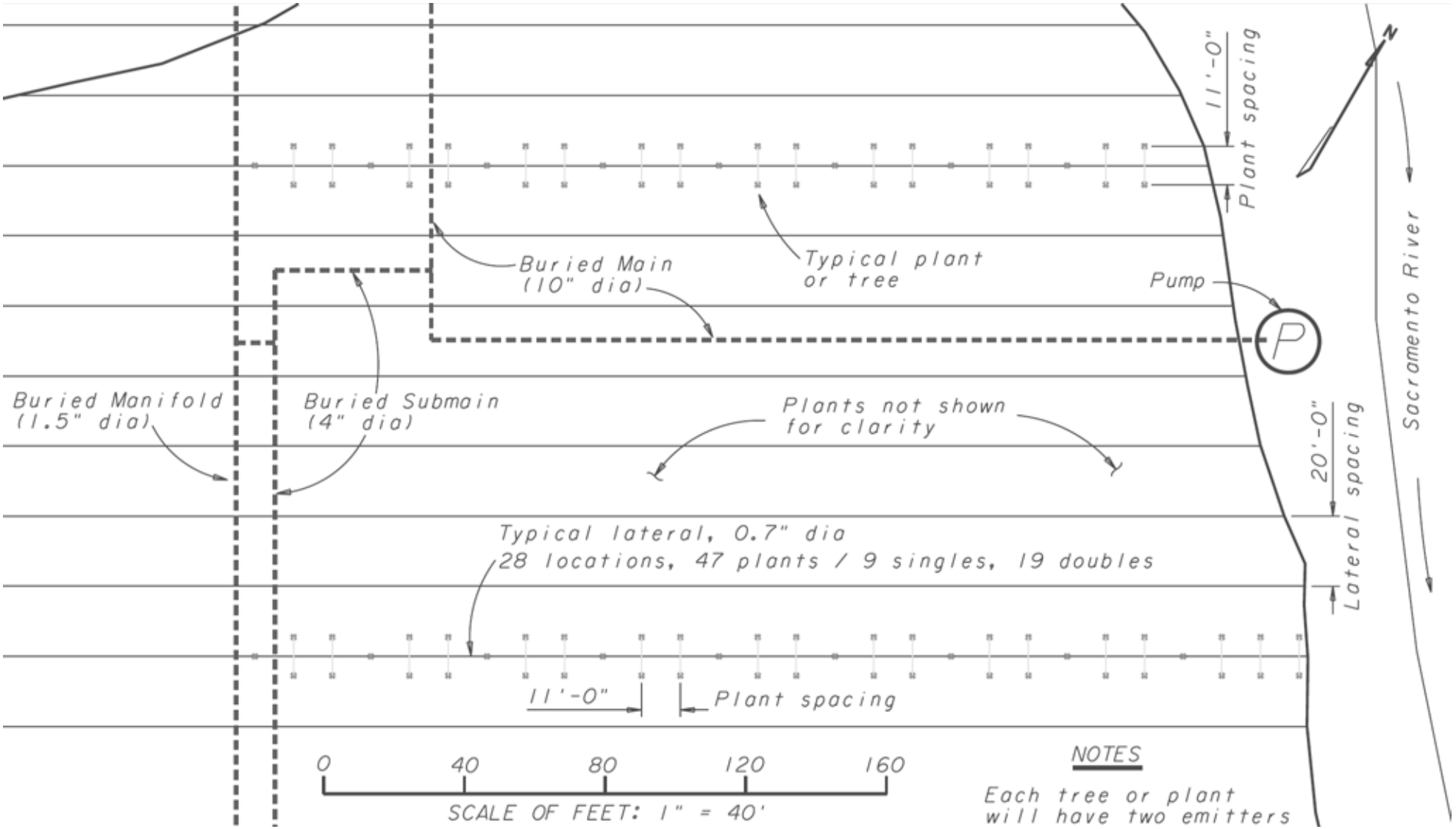
Appendix D

Colusa Ward Restoration Planting and Irrigation Plan

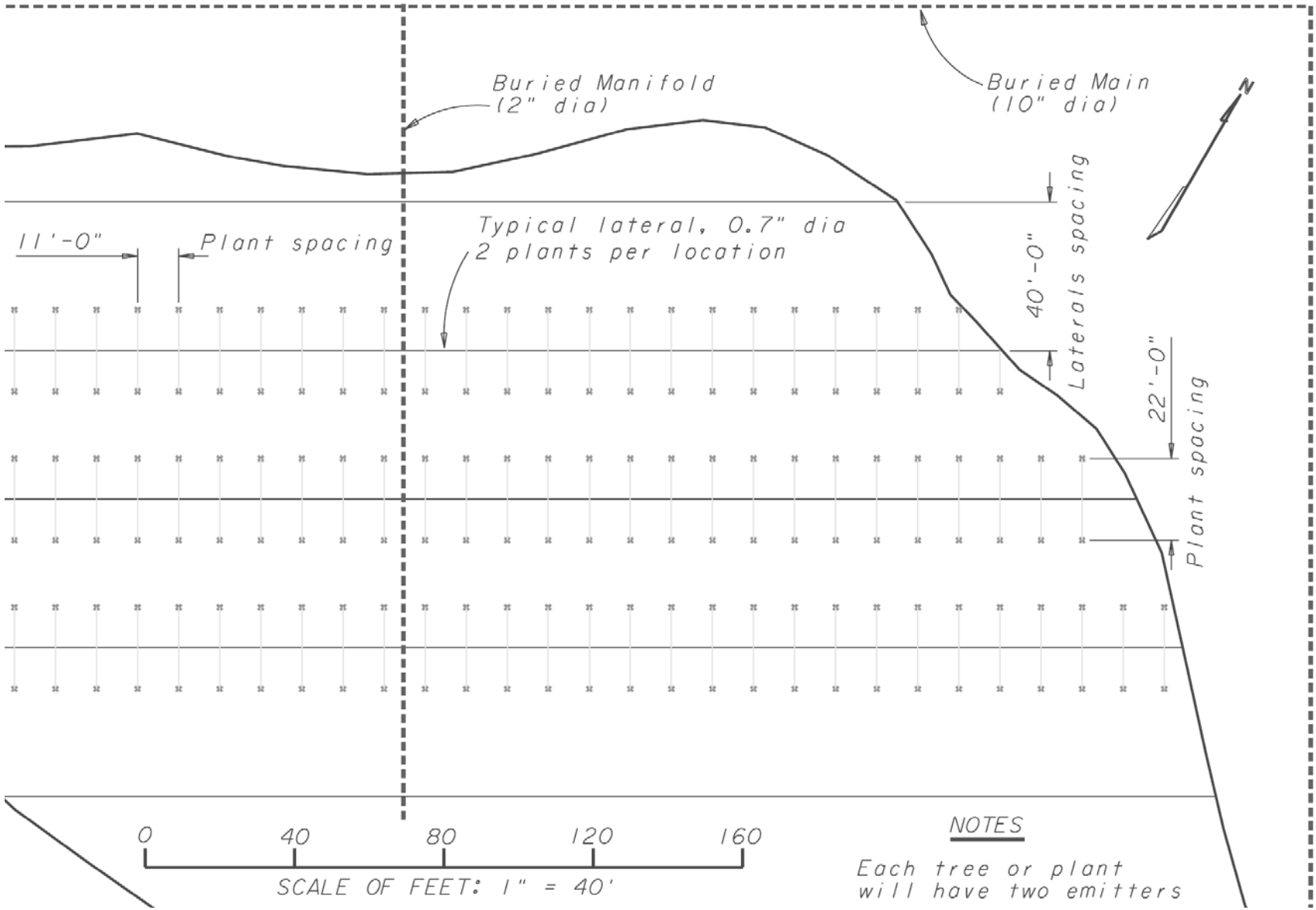
Colusa Ward Restoration Planting and Irrigation Plan



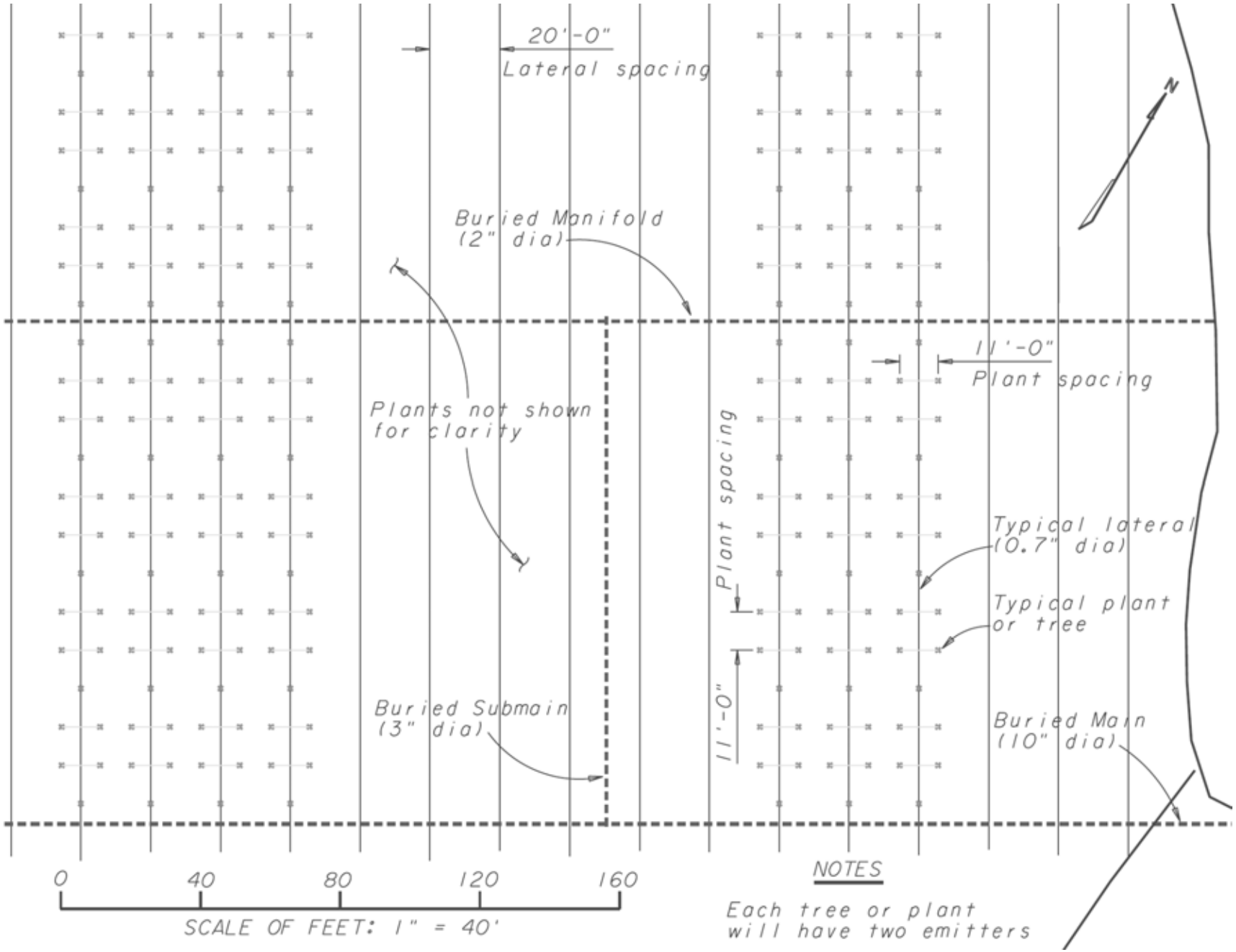
Colusa Ward Restoration Planting and Irrigation Plan
Detail A – Cottonwood Riparian Forest



Colusa Ward Restoration Planting and Irrigation Plan
Detail B – Valley Oak Savanna



Colusa Ward Restoration Planting and Irrigation Plan
Detail C – Mixed Riparian Forest



Ward Plant Propogation Costs

Greenhouse Propogation

Species	Total Plants	Cost/Plant	Nursery	Total Cost	
Western sycamore	1,662	$2.46	FNN	$4,088.06	
Valley oak	2,080	$2.00	CSU	$4,160.38	
Box elder	3,038	$2.00	CSU	$6,076.22	
Buttonwillow	855	$1.96	FNN	$1,675.73	
Oregon ash	1,052	$2.00	CSU	$2,103.95	
California rose	728	$2.00	CSU	$1,456.88	
California blackberry	1,665	$1.96	FNN	$3,263.75	
Poison oak	1,243	$1.96	FNN	$2,436.95	
Santa Barbara sedge	2,057	$0.42	HF	$864.03	
Slender sedge	1,446	$0.47	HF	$679.62	
Deergrass	52	$0.53	HF	$27.55	
Mugwort	3,364	$1.96	FNN	$6,593.09	
Western goldenrod	1,953	$1.96	FNN	$3,828.41	
California goldenrod	1,953	$1.96	FNN	$3,828.41	
Hoary nettle	537	$1.96	FNN	$1,052.67	
California pipevine	704	$1.96	FNN	$1,380.40	
Clematis	704	$1.96	FNN	$1,380.40	
California grape	792	$1.96	FNN	$1,551.74	
	25,887			$46,448.24	subtotal
				$3,367.50	tax (7.25%)
				$49,815.73	**TOTAL**

Nursery Key

FNN	Floral Native Nursery. Chico. (530) 892-2511. Contact: Germain Boivin
CSUC	CA State U., Chico. (530) 898-6023. Contact: Mark Leigh
HF	Hedgerow Farms, Winters. (530) 662-4570. Contact John Anderson. HF will h

Cutting Collection

Species	Total Cuttings
Fremont cottonwood	2,644
Narrow leaved willow	682
Goodding's willow	1,085
Red willow	682
Arroyo willow	1,446
Shining willow	555
	7,094

TNC collects approximately 95 cuttings per hour, per person.

have the seed on hand for the plants needed.

Community	**Cottonwood Riparian Forest**
Phase 1 - Manual Planting	
Density (plant by row)	11' x 20'
Density	198
Acres	29.1
Target Planting Date	Spring, Project Year 2
Total Locations	5,762
Total Plants	9,737

Canopy Structure	**Species**		**Frequency**	**Total**
Overstory	*Platanus racemosa*	Western sycamore	9%	519
	Populus fremontii	Fremont cottonwood	26%	1,498
	Quercus lobata	Valley oak	9%	519
Midstory	*Acer negundo*	Box elder	13%	749
	Cephalanthus occidentalis	Buttonwillow	6%	346
	Fraxinus latifolia	Oregon ash	5%	288
	Salix exigua	Narrow-leaved willow	3%	173
	Salix gooddingii	Goodding's willow	10%	576
	Salix laevigata	Red willow	3%	173
	Salix lasiolepis	Arroyo willow	3%	173
	Salix lucida	Shining willow	3%	173
Understory	*Rosa californica*	California rose	2%	115
	Rubus ursinus	California blackberry	5%	288
	Toxicodendron diversilobum	Poison oak	3%	173
			100%	5,243
Herbaceous	*Carex barbarae*	Santa Barbara sedge	10%	576
	Carex praegracilis	Slender sedge	3%	173
Forbs	*Artemisia douglasiana*	Mugwort	15%	864
	Euthamia occidentalis	Western goldenrod	10%	576
	Oenothera elata	Primrose	10%	576
	Solidago californica	California goldenrod	10%	576
	Urtica dioecia	Hoary nettle	4%	230
Vines	*Aristolochia californica*	California pipevine	6%	346
	Clematis ligusticifolia	Clematis	6%	346
	Vitis californica	California grape	4%	230
			78%	4,494

Phase 2 - Direct Understory Seeding

Acres	29.1
Seeding rate (lb/acre)	15
Target Planting Date	December, Project Year 2

Grass Species		**Ecotype**	**Seed Mix**
Elymus glaucus	Blue wildrye	Yolo Bypass	30%
Hordeum brachyantherum	California meadow barley	Yolo Bypass	25%
Leymus triticoides	Creeping wildrye	Yolo Bypass	45%
			100%

Community	**Mixed Riparian Forest**
Phase 1 - Manual Planting	
Density (plant by row)	11' x 20'
Density	198
Acres	64.3
Target Planting Date	Spring, Project Year 2
Total Locations	12,731
Total Plants	22,280

Canopy Structure	**Species**		**Frequency**	**Total**
Overstory	*Platanus racemosa*	Western sycamore	8%	1,019
	Populus fremontii	Fremont cottonwood	9%	1,146
	Quercus lobata	Valley oak	9%	1,146
Midstory	*Acer negundo*	Box elder	17%	2,164
	Cephalanthus occidentalis	Buttonwillow	4%	509
	Fraxinus latifolia	Oregon ash	6%	764
	Salix exigua	Narrow-leaved willow	4%	509
	Salix gooddingii	Goodding's willow	4%	509
	Salix laevigata	Red willow	4%	509
	Salix lasiolepis	Arroyo willow	10%	1,273
	Salix lucida	Shining willow	3%	382
Understory shrubs	*Rosa californica*	California rose	4%	509
	Rubus ursinus	California blackberry	10%	1,273
	Toxicodendron diversilobum	Poison oak	8%	1,019
			100%	12,731
Herbaceous	*Carex barbarae*	Santa Barbara sedge	10%	1,273
	Carex praegracillis	Slender sedge	10%	1,273
Forbs	*Artemisia douglasiana*	Mugwort	18%	2,292
	Euthamia ocidentalis	Western goldenrod	10%	1,273
	Oenothera elata	Primrose	5%	637
	Lotus purshianus	Lotus	2%	255
	Solidago californica	California goldenrod	10%	1,273
	Urtica dioecia	Hoary nettle	2%	255
Vines	*Aristolochia californica*	California pipevine	2%	255
	Clematis ligusticifolia	Clematis	2%	255
	Vitis californica	California grape	4%	509
			75%	9,549

Phase 2 - Direct Understory Seeding

Acres	64.3
Seeding rate (lb/acre)	15
Target Planting Date	December, Project Year 2

Grass Species		**Ecotype**	**Seed Mix**
Elymus glaucus	Blue wildrye	Yolo Bypass	30%
Hordeum brachyantherum	California meadow barley	Yolo Bypass	25%
Leymus triticoides	Creeping wildrye	Yolo Bypass	45%
			100%

Community **Valley Oak Savanna**

Phase 1 - Manual Planting

Density (plant by row)	11' x 40'
Density	99
Acres	10.5
Target Planting Date	Spring, Project Year 2
Total Locations	1,040
Total Plants	2,079

Canopy Structure	Species		Frequency	Total
Overstory	*Platanus racemosa*	Western sycamore	12%	125
	Quercus lobata	Valley oak	40%	416
Midstory	*Acer negundo*	Box elder	12%	125
Understory	*Baccharus pilularis*	Coyote brush	11%	114
	Rosa californica	California rose	10%	104
	Rubus ursinus	California blackberry	10%	104
	Toxicodendron diversilobum	Poison oak	5%	52
			100%	1040
Herbaceous	*Carex barbarae*	Santa Barbara sedge	20%	208
	Muhlenbergia rigens	Deergrass	5%	52
Forbs	*Artemisia douglasiana*	Mugwort	20%	208
	Euthamia ocidentalis	Western goldenrod	10%	104
	Urtica dioecia	Hoary nettle	5%	52
	Oenothera hookeri	Primrose	5%	52
	Solidago californica	California goldenrod	10%	104
Vines	*Aristolochia californica*	California pipevine	10%	104
	Clematis ligusticifolia	Clematis	10%	104
	Vitis californica	California grape	5%	52
			100%	1040

Phase 2 - Direct Understory Seeding

Acres	10.5
Seeding rate (lb/acre)	15
Target Planting Date	December, Project Year 2

Grass Species		Ecotype	Seed Mix
Elymus glaucus	Blue wildrye	Yolo Bypass	20%
Hordeum brachyantherum	California meadow barley	Yolo Bypass	25%
Leymus triticoides	Creeping wildrye	Yolo Bypass	20%
Nasella pulchra	Purple needlegrass	Llano Seco Ranch	35%
			100%

Community **Grassland (29.2 acres) and Campground (6.3 acres)**

Phase 1 Grass Seeding

Acres 35.5

Seeding rate (lb/acre) 15

Target Planting Date December, Project Year 2

Grass Species		**Ecotype**	**Seed Mix**
Elymus glaucus	Blue wildrye	Yolo Bypass	35%
Hordeum brachyantherum	California meadow barley	Yolo Bypass	35%
Leymus triticoides	Creeping wildrye	Yolo Bypass	30%
			100%

Phase 2 Forb Seeding

Target Planting Date December, Project Year 3

Forb Species		**Ecotype**	**Seeding Rate (lbs/acre)**
Artemesia douglasiana	Mugwort	Sacramento River	1
Euthamia occidentalis	Western goldenrod	Sacramento River	1
Oenothera hirsuta	Evening primrose	Sacramento River	0.5
Lotus purshianus	Lotus	Sacramento River	0.5
Solidago californica	California goldenrod	Sacramento River	1
Urtica dioica	Stinging nettle	Sacramento River	0.5

Appendix E

DWR Review of Ayers Associates' Colusa Subreach Model for Ward Tract

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

DWR Review of Ayres Associates' Colusa Subreach Model for Ward Tract Restoration

This document was prepared by:

Marianne Kirkland ..... Senior Engineer, Water Resources
Teresa Fong ..... Engineer, Water Resources
Trevor Greene ..... Engineer, Water Resources
Christopher Jones ..... Geotechnical Engineer/Engineer, Water Resources

Under the direction of:

Noel Lerner… ..... Acting Chief, Flood Maintenance Office

Division of Flood Management
3310 El Camino Avenue
Sacramento, CA 95821

December 4, 2007

Introduction

The Nature Conservancy (TNC) and the Sacramento River Conservation Area Forum (SRCAF) collaborated in Colusa Subreach Planning to engage the public in considering restoration of portions of the leveed section of the Sacramento River north of Colusa. Ayres Associates (Ayres) performed hydraulic analysis to review the existing floodplain capacity and determine the hydraulic effects of restoring habitat at eight potential sites. As guided by the Colusa Subreach Planning Advisory Workgroup and consulted Reclamation Board staff, the analysis includes modeling of the entire Colusa Subreach from Princeton to Colusa so that cumulative effects are considered.

This model review report focuses on one of the eight modeled sites, Ward Tract, which DWR proposes to restore in cooperation with The Nature Conservancy and California State Parks and Recreation (California Parks). The Ward property has been deeded to the California Parks for continuing stewardship of the land. A portion of the restoration at Ward Tract is to serve as mitigation for riparian habitat lost when DWR performed maintenance of Tisdale Bypass during 2007. Although all eight potential TNC restoration sites were evaluated in Ayres' hydraulic analysis in order to analyze their hydraulic effects along the river, DWR proposes only to restore Ward Tract. This report focuses on the modeling analysis of the Ward Tract, in support of securing an encroachment permit from the Reclamation Board.

Under contract to TNC, Ayres performed modeling to compare existing conditions with proposed restored conditions. When Ward Tract was acquired, it contained a mature walnut orchard. After acquisition, TNC converted the land to field crops in preparation for restoration. Field crops is the land use type that was input as the existing condition at Ward Tract in Ayres' model. This represents the more conservative case for purposes of change detection. The property is proposed to be restored to a mix of grassland, oak savannah, and riparian forest habitats, with maintenance requirements such as mowing to maintain the grassland explicitly identified in permitting. This report reviews Ayres' modeling assumptions and results.

Review of Modeling Assumptions

Before using Ayres' model results in their application to the Reclamation Board, DWR reviewed Ayres' modeling assumptions, as well as the modeled stage and velocity results. Modeling assumptions examined included consideration of the boundary conditions and roughness values used. To gauge appropriateness of how site conditions were characterized, DWR performed a literature review of roughness values, field-checked vegetation at several locations throughout the full reach, photo-documented site conditions, and compared what was observed to the vegetation uses assigned in the "existing conditions" model geometry file. DWR also verified the design and historical flows used, and contacted several experts with 'institutional memory' to investigate differences between design and objective flows, and the fairly wide range of flow splits recorded in historical hydrology.

Review of model methods and results was largely based on access to Ayres Draft Report and Ayres' presentation on calibration, existing conditions, and restored conditions runs. DWR staff did not re-run the model.

Boundary Conditions

The term 'boundary conditions' encompass choices modelers make about the extent of the system to model (i.e. the location of boundaries), the stage and flow to specify at the edges of the model, and which variables the model will solve for.

Model Assumptions

- The 22-river-mile model is inclusive of all eight potential restoration sites.
- The upstream boundary condition (inflow) was set to the 1957 design inflow of 160,000 cfs. Historical flow splits were specified at the weirs to achieve calibration. The boundary conditions used at Moulton and Colusa weirs were scaled up from the 1958 flow splits, at 35,700 and 73,000 cfs (+/- 500 cfs) respectively. Flow splits were scaled up from 1958 measurements because 1958 inflows to the subreach were only 2,000 cfs less than the design flow.
- The downstream boundary condition (stage) was set based on stage measurements at Colusa Bridge, adjusted for the distance between the Colusa bridge and the downstream boundary condition using the slope exhibited in the design water surface downstream of Colusa Bridge.
- Ayres checked for flow conservation within 5% through the modeled reach.

Review

- The model extent included the entire 22-river-mile reach, inclusive of all eight potential restoration sites.
- DWR verified the 1957 design inflow of 160,000 cfs and 1958 historical flow splits at Moulton and Colusa weirs Ayres reported. DWR further investigated the non-standard use of historical flow splits at Moulton and Colusa weirs. Using historical flow splits at the weirs has the effect of reducing the flow in the main stem of the river at Colusa. DWR concluded that it was acceptable to use historical flow splits at the weirs because:
    - 1) Longtime DWR and USACE engineers [Mel Yarwood, Dan Tibbitts, Don Twiss, Bob Childs, Wayne Johnson, Bud Pahl] who have worked on the Sacramento Flood Control System were asked about the potential discrepancy between design flows over Moulton and Colusa Weir, and modeled flows there. None of the engineers contacted was surprised that the system appears to be functioning differently now than at the time of Authorization. The engineers agreed that:
        - a) The Flood Control System has changed since it was first designed. Accretion in some areas and erosion others is expected to have modified capacity throughout the length of the system.
        - b) It is the Project Design Profile that is authorized, not the design flows. Project design flows were back-calculated from the Project Design Profile with much less sophisticated methods than are currently available.
    - 2) Current analysis tools allow inclusion of a greater level of detail to hydraulic analysis than was available when the Flood Control System was designed. For example, the design profile shows no water surface effect of the Colusa Bridge.
    - 3) In the three highest recorded historical events in the area, where inflow to the Colusa Subreach ranged from 157,000 cfs to 170,000 cfs, measured flow at Colusa Bridge Gage was only 44,800 to 51,800 cfs. Under the modeled flow splits 50,800 to 51,800 cfs passed the Colusa Bridge Gage.
- The downstream boundary condition (stage) was set by adjusting the rating curve value at the Colusa Bridge to account for the distance from the bridge to the downstream boundary condition.
- Summing the outflows at each outflow area (Moulton, Colusa, and the south end of the model) and comparing that total to the inflow, Ayres found conservation of flow to be well within 5%.

Bathymetry and Material Roughness

The wetted surface that water flows over, the bathymetry of the channel, is another 'boundary' of sorts that must be input to the model. Characteristics of materials (e.g. vegetation, soils, and structures) along this surface affect the resistance presented to the water as it flows. Hydraulic roughness, often referred to as Manning's 'n', represents this resistance to flow, and is an important input variable in modeling.

Model Assumptions

- The bathymetry of the reach is represented with a finite element network, or mesh. The mesh was formed from two data sources: a 1997 bathymetric survey by Ayres and 2006 LIDAR topography provided by TNC. The size and orientation of elements was varied to represent hydraulic features, structures, and topographic changes.
- Assignation of material types to elements of the mesh was based on 1998 USGS aerial photography and 2005 Natural Resource Conservation Service aerial imagery.
- Hydraulic roughness: Manning's 'n' roughness values were initially set in the high range of appropriate values based on literature review. Hydraulic roughness needed to be modified (decreased) in order to achieve a good fit in calibration of the model.
- The model is calibrated to the January 10, 1995 high flow (143,000 cfs), for which high water marks are available.
- In the existing conditions (without project) run, the Ward Tract restoration area was represented as being in crops (n = 0.035). (See **Figure 1 a**).
- In the restored conditions (with project) run, the Ward Tract restoration area was represented as being in a mix of vegetation types: grassland (n = 0.032), savannah (n = 0.045), and riparian forest (n = 0.090). (See **Figure 1 b and Figure 2**).

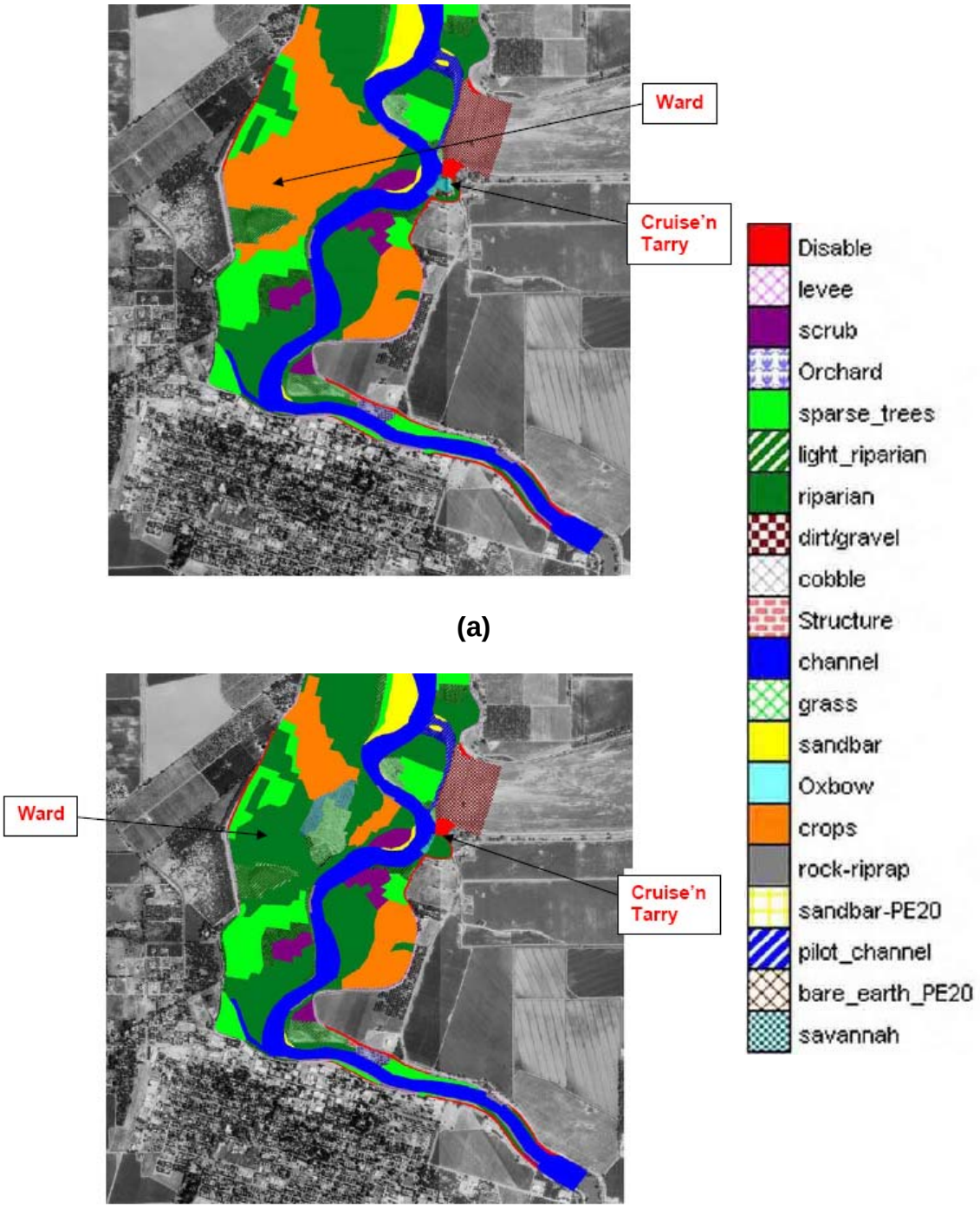


Figure 1: (a) Existing Conditions (Without Project) and (b) Restored Conditions (With Project) Land Use in the vicinity of Ward Tract, as represented in the model. (adapted from Ayres Associates)

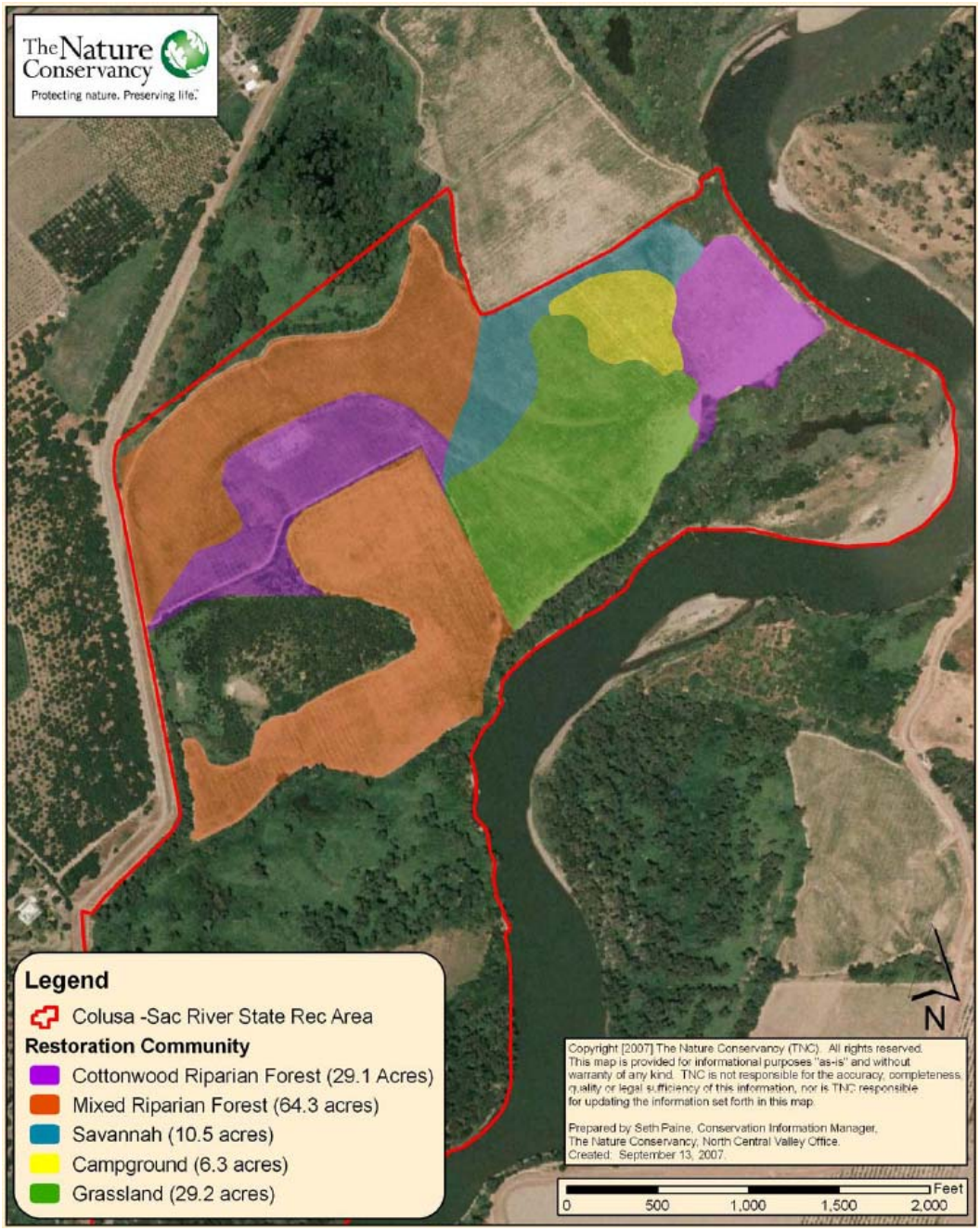


Figure 2: Representation of Land Use Types in the Restored Conditions (With Project) Model in the vicinity of Ward Tract. (The Nature Conservancy). Note that the Colusa-Sacramento River State Recreation Area property is larger than the portion of Ward Tract that is modeled to undergo changes in land use type.

Review

- The data sources are appropriate, and the bathymetry appears to capture hydraulic features, structures, and topographic changes.
- DWR staff compared the existing land use material types present in the field between RM 142.5 and 164 with those represented in the model by spot-checking the 22-mile Colusa Subreach from levees and available access points. Photographs as well as GPS readings were taken at 18 locations. DWR found that the categories used in the model closely approximated the field conditions. The modeled land use types and location of the field sites as well as select photographs can be seen in **Appendix A**.
- DWR considered both whether the current land use type matched the land use assigned in the model, and whether the roughness value assigned to that land use type appeared consistent. In **Appendix B**, a direct comparison of multiple locations with the same land use designation is displayed, to offer a sense of the similarity and variability of a given land use designation. Crops, orchard, and sand bar appear quite similar, while light riparian, riparian, and sparse trees show more variation between sites.
- The reasonableness of Manning's 'n' roughness coefficients used in the model was placed in context by reviewing five hydraulics literature sources. Overall, the values were reasonable. A table showing the literature review results is included in **Appendix C**.
- Calibrating to available high water marks for a similarly high flow event (143,000 cfs in 1995 vs. the 160,000 cfs design flow) is appropriate.
- Starting at the high end of potentially representative hydraulic roughness values and modifying them to calibrate the model is an acceptable way of achieving calibration. DWR also created a table showing typical hydraulic roughness values used for the land use types similar to those Ayres used in their model.
- The model calibration trends at or slightly above the measured high water marks, at most locations, especially along the downstream half of the model, where the Ward Tract is located. (See **Figure 3**) Ward Tract is located between River Miles 145 and 146. The calibration of the model trending at or slightly above the measured high water marks is both conservative, and an indication that raising hydraulic roughness values would reduce the closeness of fit of the model calibration.

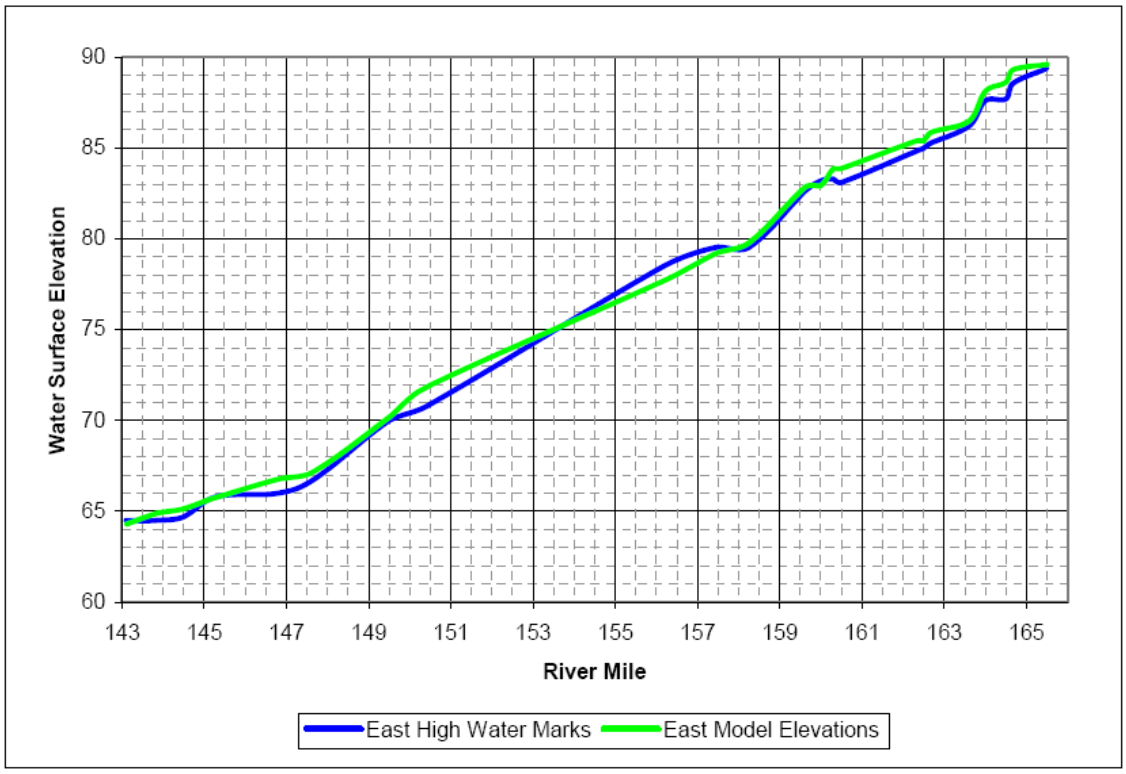


Figure 3: Comparison of Modeled Water Surface Profile with High Water Marks on the East Bank. (Ayres Associates) Note that model calibration trends at or slightly above the measured high water marks at most locations, including the vicinity of Ward Tract (RM 145 to RM 146)

- It is conservative to reflect the existing conditions, crops (n = 0.035), rather than the conditions of Ward Tract when it was purchased for restoration, orchard (n = 0.075), in the existing conditions (without project) model run. (See **Figure 1**). Setting material roughness to the lower value in the existing conditions run will predict greater change when comparing restored condition results with existing condition results.
- The distribution of vegetation types in the restored condition (with project) run creates an overbank flow corridor where the low hydraulic roughness of the grassland (n = 0.032) and savannah (n = 0.045) are placed. (See **Figure 2**). This will encourage some of the water that would otherwise have flown around Cobb's Bend to short-cut across Ward Tract. This will tend to keep stage low.

Interpretation of Model Results

Having considered the modeling assumptions, it is also important to interpret model results carefully, and to consider model results in context. To understand how to compare the design profile with modeled results, one needs to consider the level of detail inherent in each. Some guidance on how to interpret color-coded figures is also provided in this section.

USACE Flood Control Project requirements are specified in terms of a design water surface elevation profile (design profile). The design profile is specified along the Sacramento River with a single elevation at any given cross-section. The design profile is provided in graphic format (as contrasted with tabular format) and values at any given location may be interpolated, by eye, from the graphic. **Figure 4** shows the level of detail specified in the USACE channel design profiles, which are available electronically on the Reclamation Board web page at http://recbd.ca.gov/profiles/ Hatch marks delineate elevation change every 2.5 feet.

The format of the water surface elevation results from the model is very different; model results are two dimensional, showing more of the actual complexity of flow patterns. (See **Figure 5**). The shades of blue in **Figure 5** represent ranges of water surface elevation. Two dimensional modeling examines localized results that it would not be possible to discern in one dimension, where every cross-section would use average values. For use in the two dimensional model, the one dimensional information contained in **Figure 4** was applied across the finite element mesh shown in **Figure 6**.

In graphics of model results that follow **Figure 6**, color coding is used to illustrate differences in water surface elevations among the USACE 1957 design profile, existing conditions (without project), and restored conditions (with project). Cool colors (greens, blues and purples) on comparison plots indicate negative values, areas where the modeled condition compared is below the design profile. Comparison plots also leave areas where values within a specified range transparent, allowing the background aerial photograph to show through. Higher values are indicated by the warm end of the color spectrum.

Similar conventions are used to portray velocity distributions and changes in velocity distribution. Existing conditions, as well as changes in velocity distributions, affect resultant conditions. For example, an increase in velocity of 0.5 ft/sec could result in erosion or deposition, depending on the initial conditions in an area. Unlike the water surface elevation results, the velocity results contain no comparison to design conditions because there are no design velocity conditions with which to compare. In interpreting results, it is important to be mindful of whether a given plot illustrates water surface elevation or velocity. Attention to the units used (ft or ft/sec) is useful in differentiating between water surface elevation and velocity-related plots.

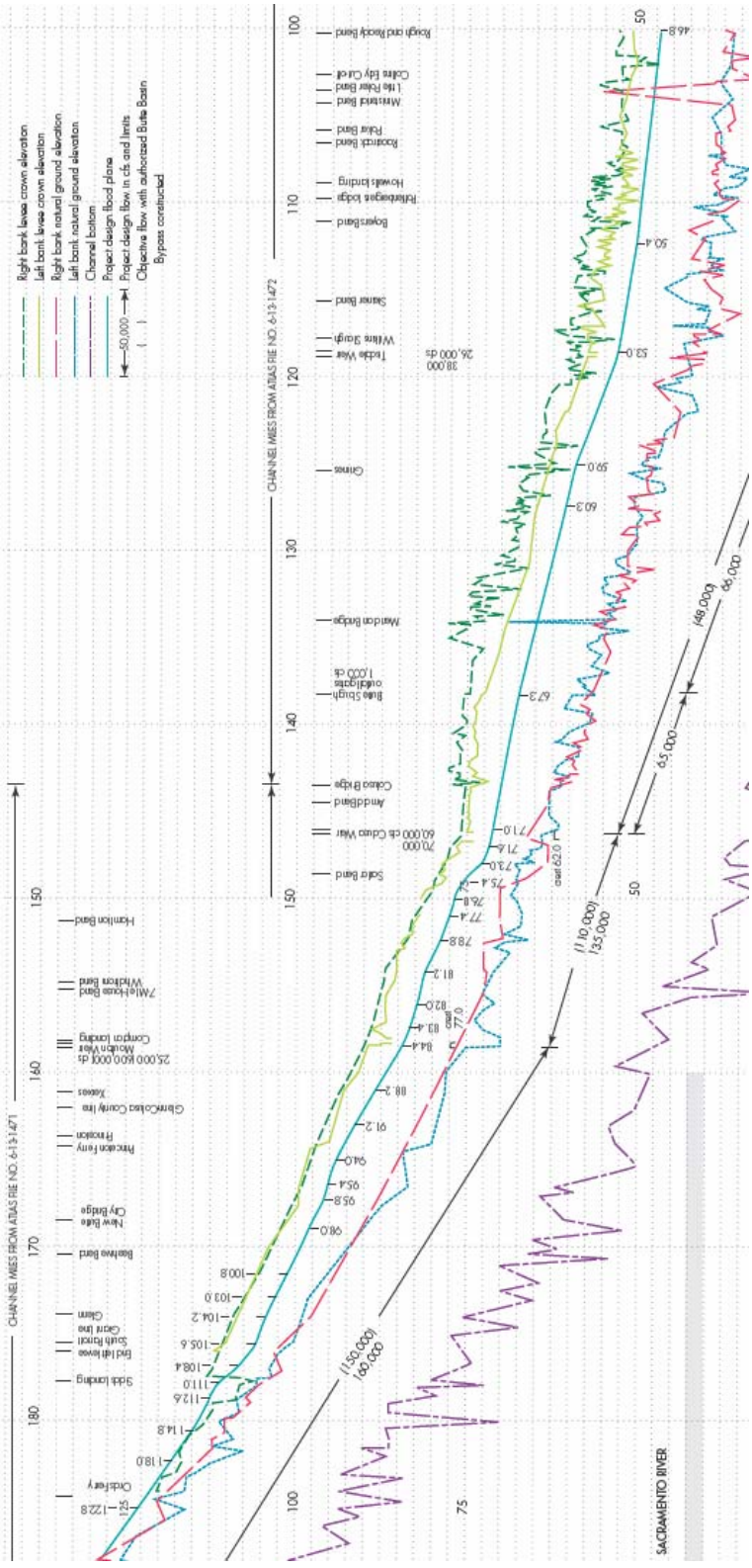


Figure 4: Excerpt from Sacramento River channel design profiles (Reclamation Board electronic conversion of original USACE profiles)

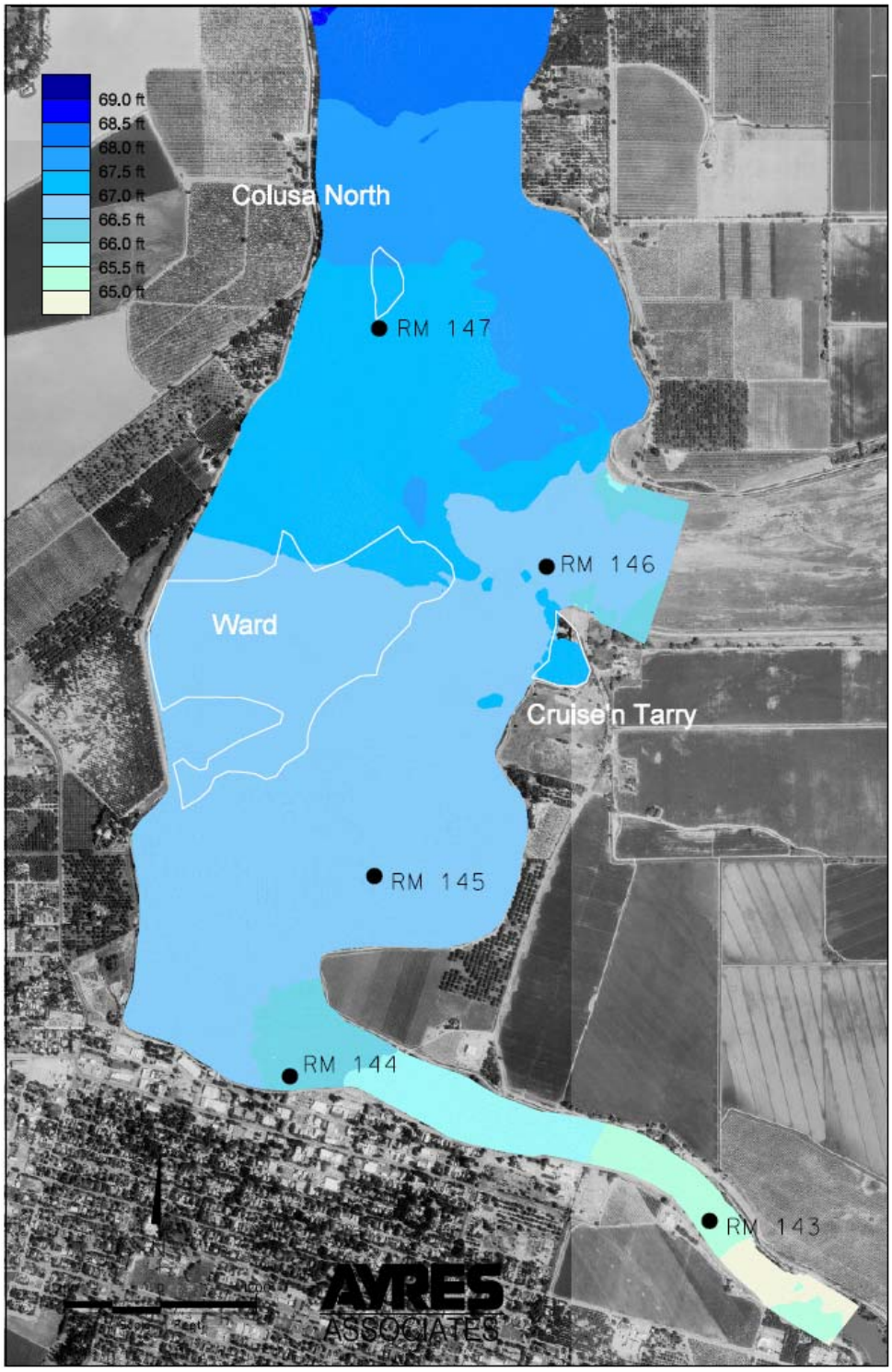


Figure 5: Example of two dimensional results: modeled water surface elevation, Existing Conditions (Without Project) (Ayres Associates)

While two dimensional modeling shows much more detail than one dimensional modeling, the scale of the elements in the model is on the order of thousands of square feet, not small enough to represent individual trees, nor fine enough to perfectly represent a curving levee wall. (See **Figure 6**).

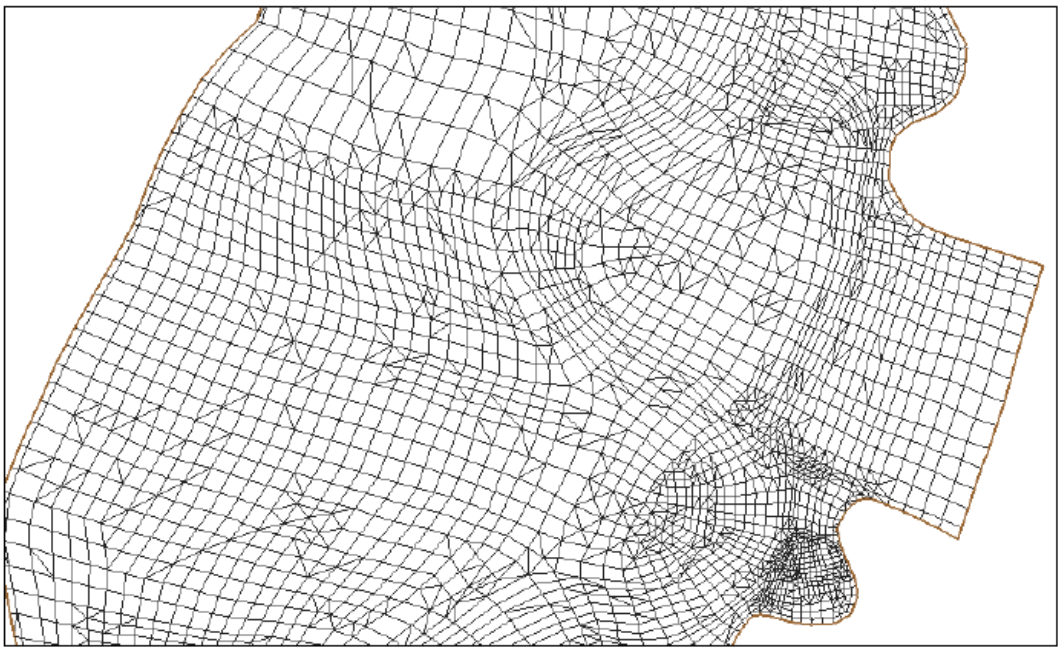


Figure 6: Example of finite element mesh (Ayres Associates)

One should also be aware that there is error in field measurement of land and water elevations, and calculation of flows. Confidence in measured flow measurements may range from +/- 5% to +/- 15%. While the modeled restored conditions did result in a slight (1,000 cfs, ~1 %) increase in flow over Colusa Weir, this change is small when considering potential flow measurement error.

	Existing Conditions Model	Restored Conditions Model
Inflow to Subreach	160,000 cfs	160,000 cfs
Moulton Weir	35,700 cfs	35,700 cfs
Colusa Weir	72,500 cfs	73,500 cfs
Channel below Colusa	51,800 cfs	50,800 cfs

There are several potential sources of error in stage measurement. High water marks pose a special problem where wind waves may be significant, and it may be difficult to tell whether high water reached the top or bottom of a wide swath of debris. There is also rounding error inherent to intensive calculation methods. Just because computer results can be generated to many places past the decimal does not mean those are all significant digits. Taking results to be meaningful to approximately 1/10th of a foot is common practice.

Stage

Model Results

- Model results indicate that for eight river miles upstream of the Ward Tract property, and three river miles downstream of it, under existing vegetation conditions, when 160,000 cfs enters the Colusa Subreach, the water surface ranges from 0.25 to 3 feet below the design profile. (See **Figure 7** to view River Miles 144 through 147, and Ayres' report for graphics of more distant sites). In the immediate vicinity of Ward Tract, the water surface ranges from -0.5 to -1.5 feet below the design profile. Note that the design profile itself is at least 3 ft below the levee crest.
- With the project's proposed restored vegetation conditions, the water surface remains 0.25 to 3 feet below the design profile (See **Figure 8**). There are some slight localized water surface differences (both positive and negative) compared to modeled existing conditions (Compare **Figure 7** and **Figure 8**)
- **Figure 9** isolates the difference between existing conditions and restored vegetation conditions. The yellow triangle indicates the area upstream of Ward Tract where there would be an approximately 0.1 ft rise in water surface elevation. The maximum rise in water surface elevation along the west levee is 0.12 ft. The maximum rise in water surface elevation within the yellow triangle shown is 0.15 ft. The maximum rise in water surface elevation along the eastern levee, north and south of the Colusa Bypass is 0.03 and 0.01 ft respectively.
- The cross section shown in **Figure 10** compares the differences among the design profile, existing conditions (without project) water surface elevations, and restored condition (with project) water surface elevations. This cross-sectional location along the upstream portion of Ward Tract was selected for illustration because it cuts through the area that is modeled to undergo 0.1 to 0.2 ft of water surface elevation rise, as shown by the yellow triangle in **Figure 9**.
- **Figure 10** also illustrates freeboard at the levees, and the typical water depth over Ward Tract under the modeled high flow scenario. It indicates a typical difference between the restored conditions (with project) water surface elevation and the design profile of 0.86 ft. The difference shown between existing (without project) and restored (with project) water surface elevation at this cross section is 0.11 ft.
- **Figure 11** provides a map key showing the location of the cross section provided in **Figure 10**.

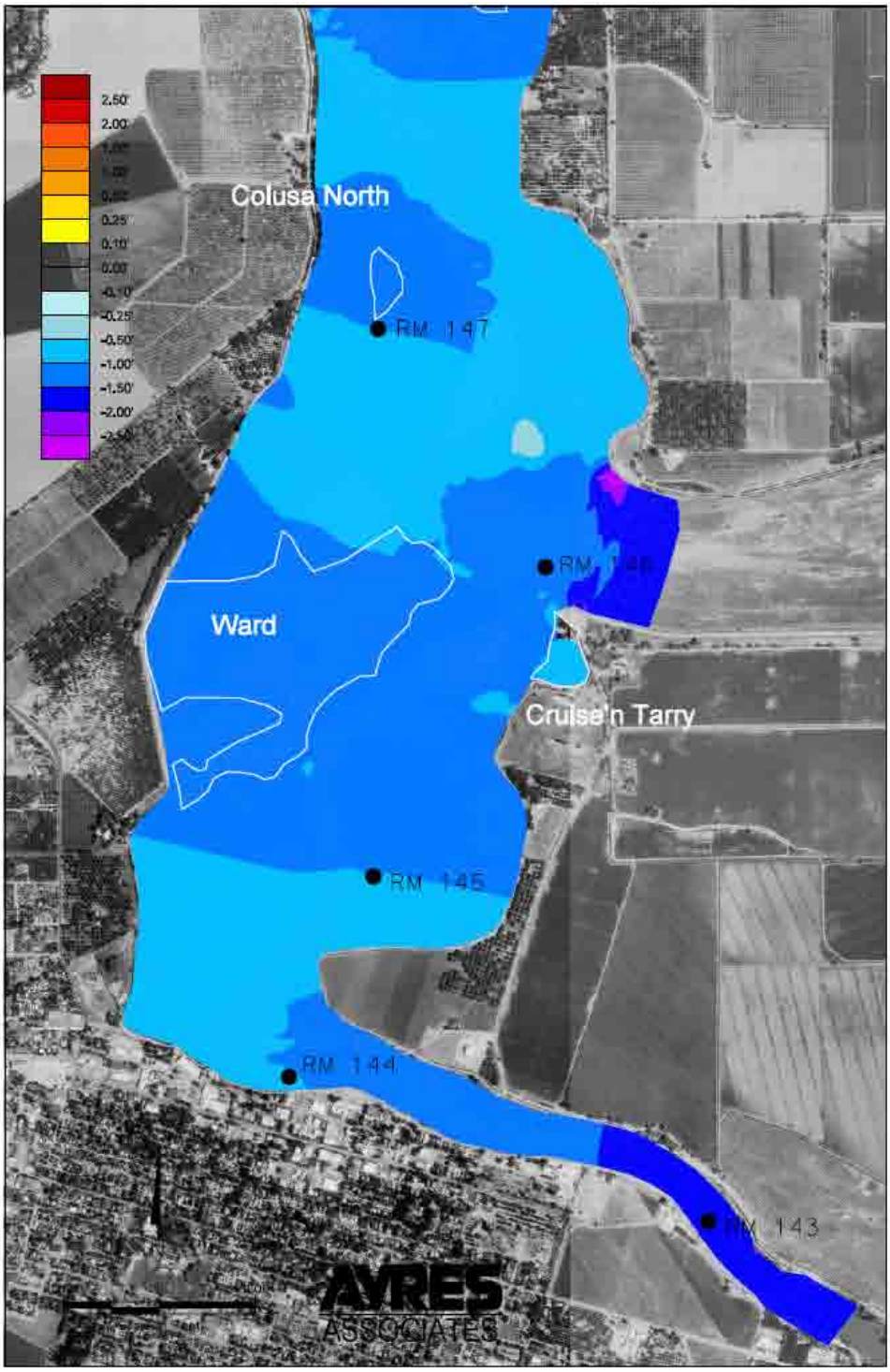


Figure 7: Difference between Design Profile and Existing Conditions (Without Project) modeled water surface elevations (Ayres Associates)

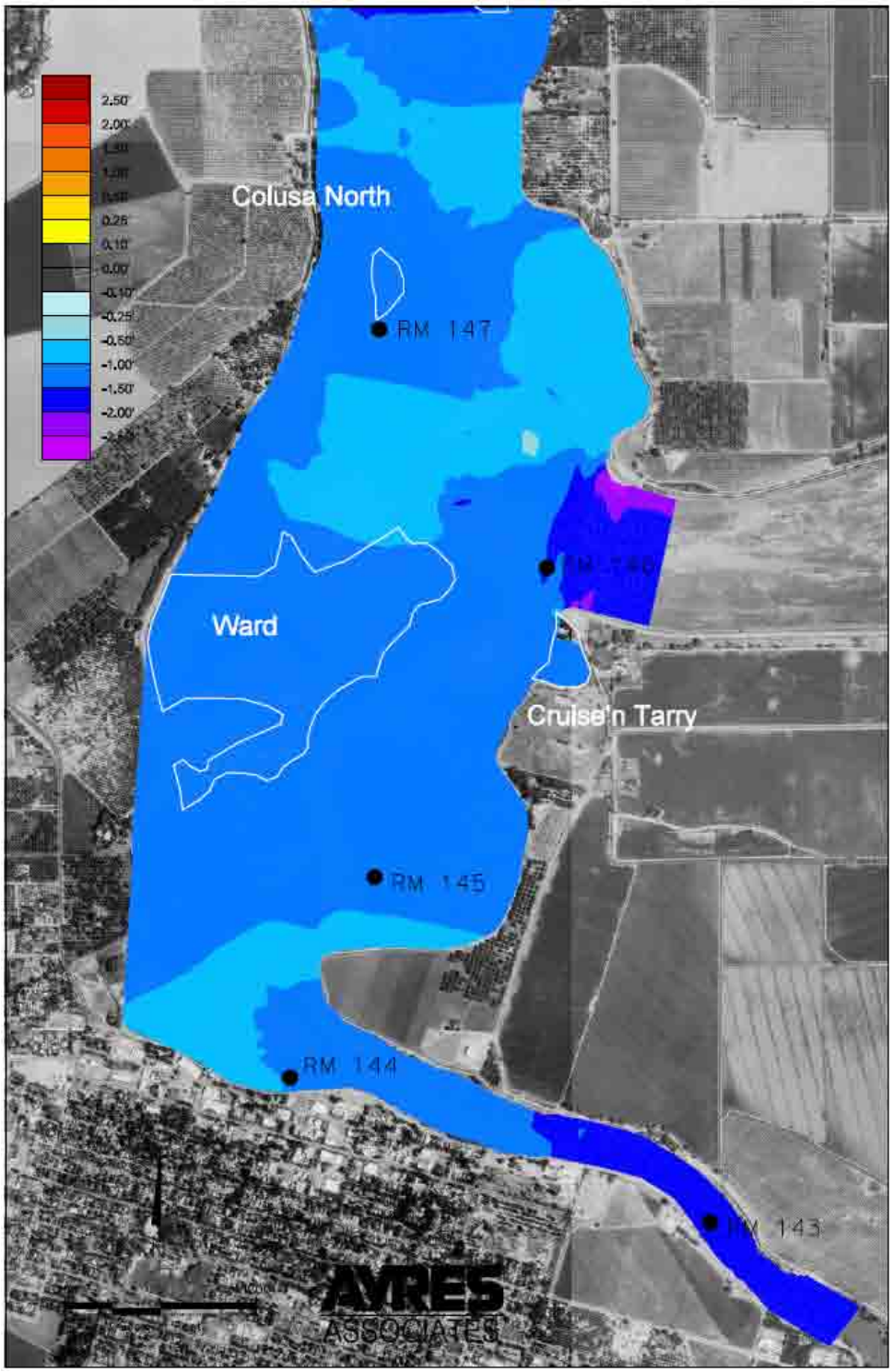


Figure 8: Difference between Design Profile and Restored (With Project) modeled water surface elevations (Ayres Associates)

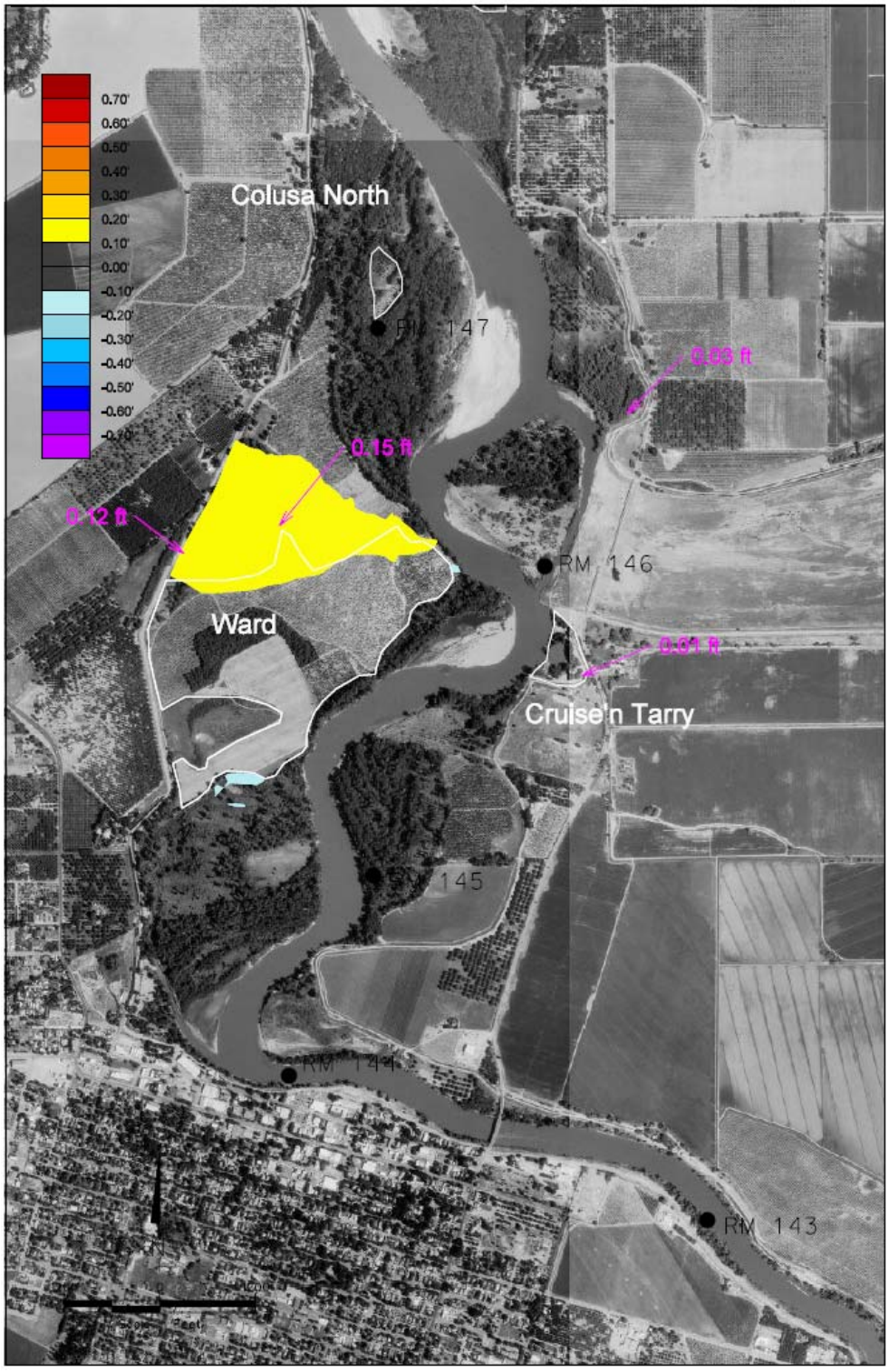


Figure 9: Net change in Water Surface Elevation; Difference between modeled Existing Conditions (Without Project) and Restored (With Project) water surface elevations (Ayres Associates)